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Solubility of halite (NaCl) in water vapor at 400-700°C

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Salt-bearing water vapor at high temperatures plays an important role in various geological and engineering processes, such as ore deposit formation and supercritical water oxidation. However, understanding the solubility of salts under such extreme conditions can be challenging due to the difficulty of conducting experiments at elevated temperatures and pressures. Here, we introduce a state-of-the-art U-tube flow-through reactor system capable of operating at 350-800°C and up to 400 bar pressure to determine solid solubility from both supersaturated and undersaturated solutions. The compact and flexible design of the U-tube reaction system allow for rapid experimentation and data collection. Constructed from ultra-high temperature-resistant Hastelloy-276 tube, this experimental apparatus ensures durability under extreme conditions. We present the results of experimental measurements of halite (NaCl) in water vapor at temperatures of 350-700°C and pressures of 25-300 bar. The experimental data were interpreted in terms of hydration of the neutral gaseous neutral NaCl(s) gas species with solubility of halite increasing with increasing pressure due to increased hydration (addition of H_2O) with increasing pressure. Moreover, the stoichiometry typically reflects the Cl/Na ratio of 1:1; however, non-stoichiometric reactions were observed, with Cl/Na ratios of up to 9:1 with increasing temperature consistent with hydrolysis of NaCl to NaOH. Based on the experimental results and data processing, thermodynamic values (ΔGr, ΔHr, ΔSr, ΔCp,r) have been obtained for the solubility halite to form hydrated neutral NaCl gas compounds as a function of temperature and pressure. These values are subsequently utilized to model NaCl transport behavior in upper crustal environment.The project has received funding from the European Union’s Horizon 2020 under Grant Agreement #818169 (GeoPro).